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The development of a clay body with compatible glaze formulae

Nancy Travers
Portland State University

AN ABSTRACT OF THE THESIS

THE DEVELOPMENT OF A CLAY BODY WITH COMPATIBLE GLAZE FORMULAE

Nancy Travers for the Master of Science in Teaching

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There are two aims in this thesis: the first is to ascertain something of the physical and chemical properties of clay and glazes and how to handle and control them. A project such as the development of a clay body and glaze formulae serves to isolate the various functions of the materials and give a clear understanding as to their use and potentials. This enables one to visualize and manipulate materials creatively with a reliable prediction as to their behavior. Spencer Moseley in Art Education supports this, saying: "The quality of a man's production depends upon (1) the idea, the ability to think through all the processes in relation to the object planned and the materials used; and (2) his ability then, to fashion these materials with skill."[1]

The second aim is to examine the application of a study of clay bodies to a high school or junior college teaching level. Although the

[1] Spenser Moseley, "Design as a Common Denominator of the Crafts," Art Education XVII (Nov. 1964), 8-13.

complexity of working out a clay body and the time involvement in doing it would not readily lend themselves to these teaching levels, the goal is to present a simplified teaching presentation of the technical data and to develop an attitude which will integrate the project.

THE DEVELOPMENT OF A CLAY BODY WITH
COMPATIBLE GLAZE FORMULAE

A THESIS

BY
NANCY TRAVERS

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AN INTRODUCTION

A project such as the development of a clay body must be seen in its broader scope in order to understand its value and purpose. This project is an integral part of a concept which progresses from pottery to crafts, to art education and finally to today's society. If one starts by contemplating today's society and works back it will enable him to understand the total picture.

The Industrial and now the Cybernetics Revolution have confronted man with major changes in his living pattern. Leisure time has increased and the work day has developed into a block of time, which can be devoid of emotional satisfaction. In his job situation he has in many instances a replacement for his muscular activities and less demand on his mental powers. He can eliminate physical labor with the push of a button or can acquire information with a turn of the wrist (TV, radio, hi-fi, or inter-communications systems, etc.). Leisure and working time can easily be spent with a preponderance of passive involvement where all outside stimuli come in and one fails to analyze, observe and outwardly express his emotions and ideas. Outward expression can be called creativity and is vital to man's existence. Moholy-Nagy says, "To live without this, means emotional starvation just as missing food means starvation to the body."[1]

Creative activity is the means by which man develops his

[1] Laszlo Moholy-Nagy, Vision in Motion (New York, 1962), p. 28.

intuitive learning, aesthetic growth and understanding. Prior to the Industrial Revolution, creativity was a part of everyday existence. As a matter of necessity the average man had to create his own food, clothes, home furniture, entertainment or other living requirements not provided by technology. Today, man's environment provides less need to create and he seeks new avenues to furnish this lack. Evidence of this is the cultural revolution taking place in the United States. And most significant is the increase of people becoming personally involved in the creative field through adult education. Here an increasing number of classes are being opened and the demand is great in the art classes, according to Jerry Hesling, Director of Adult Education in Lake Oswego, Oregon.

Art education has two functions. First, the development of creative thinking and, second, the perfection of skills that will give a firm foundation to the creative endeavor. Creative thinking follows a logical sequence of thought. It is characterized by (1) preparation, (2) incubation, (3) illumination, and (4) verification. Creative thinking can be little exercised, thwarted by emotional blocks and difficult for some people. They are fearful of expression, striving for perfection, a quality of their technological environment and the great minds and accomplishments that are a part of their everyday lives through mass media. This fear produces a paralysis of creative attempts.

While encouraging creativeness, the teacher must also offer direction in craftsmanship and technique. This should safeguard against a prevailing program which over-emphasizes the acceptability of originality and erroneously puts total value on original self expression to the detriment of craftsmanship and a knowledge of design. Art Education has this to say about such a program:

> It is generally felt that verbalization and research stifle creativity. This practice of skills such as calligraphy, perspective, design exercises, and color problems are sacrificed to the stimulation of the imagination through 'motivations.' The emphasis on the irrational and the absurd is often reflected in these exercises emulating the professional 'avant gard.' Craftsmanship and technique are considered incidental to the overwhelming acceptance of originality as a criteria of a work of art.[2]

The problems set up in an art education course should act as self-development through self-effort. Each problem serves as an exercise towards the solution at hand or for problems in general. The process of creation, followed by the act of doing, must be an outgrowth of one's own experiences. Each design becomes an experiment, each line a problem to solve. All the universal laws are in operation and the knowledge gathered heightens intuition. This unconscious knowledge becomes an emotional or spiritual element as opposed to the more intellectual laws of mathematics and geometry governing design. Intuition gives the solution for what we feel is best for a problem, art or otherwise. With this development follows a development of aesthetics. This is an instinctive tendency to achieve beauty.[3]

The next responsibility of an art program is the development of skills and technical data. This information is of a concrete nature

[2]Ida Shimans, "Cultural Explosions," Art Education XIX (June, 1966), 3-8.

[3]See Adolfo Best-Maugard, A Method of Creative Design (New York, 1949), p. 124.

and is often sought out by unimaginative teachers and students as a safe haven. This is especially true in the how-to-do-it courses where students are encouraged to paint from photographs, copy patterns, or pour slip into molds. The emphasis is on accuracy of technique with the imagination fitting into a preconceived plan. Without the creative thought processes, the skills and technical information become mechanical operations devoid of artistic expression.

Ideally speaking, the creative and technical should be interrelated with one supporting the other and direction given to both. Technical data is essential to the craftsman in the preparatory phase of his creative thinking. Here, the development of a clay formula fits into the scheme. By isolating the components so that one can experience a systematic unfolding of the functions, the potter achieves a clear and thorough understanding of his materials. This is a prerequisite to the invention of the new effects and combinations. One will find a relationship between productive creative thinking and knowledge or past experience. The creative spark can at times seem to come from nowhere, but in actuality it is synthesized information which has become a part of the unconscious. This unconscious thinking is a result of extensive preparation.[4]

In applying the testing procedures which follow, the teacher must keep in mind the relationships of this project to the over-all goals of Art Education. There is a great danger of letting a project such as this become an end in itself because it is a safe activity in a

[4]See Catherine Patrick, <u>What is Creative Thinking</u>? (New York, 1955).

field which should always be exploring, observing and pushing towards the new.

DEVELOPMENT OF A CLAY BODY

The clay used for the project is mined in Astoria, Oregon, sold and distributed by Maynard Christiansen, 3390 S. Mapleton Drive, Lake Oswego, Oregon and has the trade name of Clatsop Clay. It can be purchased in either a dry powder form or pugged in plastic bags. This particular clay was chosen for the project because it is available locally and is in pure form from the mine. This eliminated the problem of digging one's own clay, an activity which did not have value at this time.

Several reports had previously been done on the clay. These were by geologists and have little value to the potter other than to serve as a starting point or to indicate complete rejection as a potter's clay. The report from the State Department of Geology and Mineral Industry provided the most significant information. The information was as follows:

Dry color	tan
Wet color	brown
Plasticity	42%
Dry behavior	satisfactory
Firing behavior	good
Drying shrinkage	11%

Behavior at Cone 04-1958° F

Color	buff brown
Shrinkage	5.9%

Behavior at Cone 02-2030° F

Color	buff brown
Shrinkage	8.5%

(Shrinkage at Cone 04 and 02 is in addition to the dry shrinkage.)

Clay is by chemical analysis made up of alumina, silica and water. In actuality it is more complex and contains metal oxides and impurities. Dug directly from the ground, it can rarely be used by the potter without further adjustments to meet his purposes; hence, we have a clay formula.

The potter uses clay for various purposes and varies the formula accordingly. A throwing clay may be different from one designed for large hand-built pottery or that used for clay sculptures. Each formula has three divisions of materials and these are adjusted according to the needs. The three divisions are: plastics, non-plastics and fluxes.

Plastics are the materials that add plasticity to the body. Plasticity means the ability of the clay to "stretch" and this varies from clay to clay. This is the result of the physical composition of clay, which is made up of plate-like particles that slide one against the other. The finer the particles, the more plastic the clay, since there is more surface area to slide. Fine particle clays are earthenware, ball clay and bentonite. Clays not in this category need the addition of a more plastic clay for workability. Clay which is very plastic causes trouble in drying, as the particles are so fine and close together that the water cannot escape from the interior. Therefore, uneven drying and warping result. This requires a non-plastic for correction.

Non-plastics are materials with little shrinkage in themselves. They allow the clay to dry safely without undue warping and cracking.

These materials leave open spaces between the clay which allow for more even evaporation and help to reduce warping. Non-plastics also reduce total shrinkage of the clay body.

Suitable non-plastic materials are flint, grog, sand, fire clay and kaolin. These materials all react on the clay body in another way and this must be considered. Flint, fire clay, kaolin, and sand are refractory and raise the firing temperature. Sand is silica or flint but has a larger particle size which may be desirable in certain situations. Flint should be limited to 15 per cent but less than 10 per cent gives difficulty in fitting the glaze. Grog is fired clay ground to a given particle size. The particle size and type of clay used will vary the amount of reaction within the clay body. A coarse particle, high fire grog will react less in a stoneware body than a fine low fire grog. Non-plastics should not exceed 25 per cent of the total materials.

Fluxes make up the third category. These materials aid in lowering the melting point of the clay body. This is necessary because clay is composed primarily of silica, with a melting point of 3100° F. Fluxes lower this temperature to the requirements of a stoneware body, ranging from 2250-2400° F. Feldspar is the chief flux. Coloring oxides such as iron and manganese are fluxes but usually do not become critical. If, however, one is having difficulty in reaching the desired firing temperature because of a low vitrification point of the clay as was the case with the Clatsop Clay, then any additional fluxing materials can become important. Fluxes affect vitrification of the clay body and subsequently decrease the absorption. Vitrification is a hardening, tightening and ultimately the glassiness of the clay. A completely vitrified body would be glass-like, very dense and with no absorption. The potter stops short of this state in his firing and aims at a stoneware body with 1-6 per cent absorption. One can adjust the clay body to obtain this point by adding a flux or refractory material for adjustment of the vitrification point.

To clarify the above information, the following chart will be helpful. It indicates the area of correction, materials which bring about this correction and disadvantages of these materials on the clay body if used to excess.

AREA OF CORRECTION	MATERIALS	DISADVANTAGES
WORKABILITY	PLASTICS ball clay plastic fire clay bentonite	causes cracking and warping
DRYING WARPING	NON-PLASTICS grog fire clay sand flint kaolin	all materials are refractory with the exception of grog flint and sand in excess cause dunting
VITRIFICATION ABSORPTION	FLUXES feldspars earthenware clay metal oxides talc dolomite	feldspar, talc and dolomite are non-plastic used in excess cause slumping

TESTING PROCEDURES

First, test the basic clay to be used in the formula. This will give one an idea of its characteristics and where corrections are needed. Prepare a small amount of clay (ball with a 6" diameter) and run the following tests, leaving some in the dry state until after the first test.

WATER OF PLASTICITY

This test indicates the plasticity of the clay. A clay will ideally absorb between 25-30 per cent water. Any amount above or below this range is likely to be a sign of future problems. Use the following formula for this calculation:

$$\text{Water of plasticity} = \frac{\text{Wt. of plastic sample} - \text{wt. of dry sample}}{\text{wt. of dry sample}} \cdot 100$$

WORKABILITY

Throw a small pot with the clay. Make a shape that is pulled outward. A good clay should cantilever about 6" beyond the base without cracking along the edge. If the clay is too plastic it will be sticky and hard to handle. For a more accurate test, let the clay age a minimum of one week.

SHRINKAGE

Draw a line of 10 cm. on a bar of clay and mark the firing temperature on the bar. After firing, measure the line and the decrease in the measurement of the line will be the percentage of shrinkage. For example, if the 10 cm. line shrinks to 8 cm. the shrinkage is 20 per cent.

DRYING

Throw large and flat pieces, letting them dry at room temperature. Cracks will occur horizontally and vertically if there is an inadequate amount of non-plastic present in the clay body.

SLUMPING

Make a bar of clay, 10" by 1½" by ½". Support this bar in the kiln with two 1½" Skutt kiln supports under each end. After the firing, note the amount of sagging between each support. Record the slumping on a scale of 1 to 4. One represents no slumping, two, if there is ½" slumping from the horizontal, three, if there is 1" and four, if there is 1½".

ABSORPTION

After the clay bar used for the shrinkage test has been fired, weigh it and then soak overnight. Remove the bar and wipe off excess water. Weigh again and use the following formula:

$$\frac{\text{Percentage of}}{\text{absorption}} = \frac{\text{Saturated wt.} - \text{dry wt.}}{\text{dry wt.}}$$

DUNTING

This is a vertical cracking which takes place in the cooling of the glaze fire. It can be caused by an excess of flint, usually over 25 per cent or by cooling the kiln too fast.

COLOR

Note the color after the glaze firing.

Record the results on a chart set up as follows which will hereafter be referred to as the Clay Test Chart. The first column indicates the tests to be performed. The second column gives the limits for each test within which the Cone 6 and 10 clay formula must fall. The third column gives the results of the tests on 100 per cent Clatsop Clay. The additional columns leave spaces for the recording of any further results as the clay formula is developed. The two final formulae are recorded in these spaces.

CLAY TEST CHART

TESTS	LIMITS OF MATERIALS	CLATSOP 100%	CONE 6 BODY	CONE 10 BODY
WATER OF PLASTICITY	25-30%	30%	25%	23%
WORKABILITY	Plasticity which varies with purpose	poor	good	good
SHRINKAGE	10-25%	20%	18%	15%
DRYING	satisfactory at room temperature	poor	good	good
SLUMPING	1-2	3	2	2
ABSORPTION	1-6%	0%	5%	2%
COLOR	———	dark brown glassy	orange brown	warm brown
DUNTING	none	none	none	none

After the characteristics of the primary clay have been determined, isolate each part that needs correction. Start with workability. This involves its performance as a throwing clay, or sculpture clay and the required plasticity directly affects the drying. If the clay is too plastic, add a non-plastic. If it is not plastic enough, add a more plastic clay such as bentonite or ball clay. Start by using a 75 per cent total clay proportion with 25 per cent left for the fluxes and non-plastics. The Clatsop Clay is not plastic enough so a ball clay was added in increasing proportions. Measure out the amounts by parts rather than weight. This makes it easy to vary the size of the sample prepared. Set up a chart as follows to record the results.

MATERIALS	TEST 1	TEST 2	TEST 3	TEST 4
CLATSOP CLAY	70	65	60	
BALL CLAY	5	10	15	

RESULTS

PLASTICITY	poor	good	good	
DRYING	poor	poor	poor	

Tests 2 and 3 were satisfactory. Therefore, using Test 2 set it up in the Clay Testing Chart to determine what the new material has done to the original calculations and where further corrections need to be made.

After the workability is adjusted, then work to control the drying. This is corrected by adding a non-plastic. Throw objects with large, flat bottoms. This shape will crack first, if the drying properties are not correct. Too much non-plastic material will cause the pot to simply fall apart because it decreases the dry strength. This fault can be mistaken for cracking. Record the new addition of non-plastic materials on a chart like the previous one and hold the plastic materials constant and vary the non-plastics.

MATERIALS	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5
CLATSOP CLAY	65	65	65	65	65
BALL CLAY	10	10	10	10	10
FLINT	20	15	10	10	10
FELDSPAR (KINGMAN)	5	10	10	5	5
SAND				5	
GROG					5
FIRE CLAY			5	5	5

RESULTS

PLASTICITY	poor	poor	good	good	poor
DRYING	good	good	good	good	good
OTHER					cuts dry strength

Test 4 turned out to be satisfactory so it should be retested according to the Clay Test Chart.

The results from the Clay Test Chart on Test 4 turned out favorably with the exception of its plasticity. It could be a little more plastic. It was also slightly glassy. These minor changes were corrected without testing. A refractory, plastic fire clay, replaced the ball clay.

The final clay body which was worked out with Clatsop Clay has two formulae. One is designed for Cone 10 which is the temperature commonly used with fuel-burning kilns. The second is a clay body for an electric kiln which is usually taken to Cone 6.

CONE 6 BODY

MATERIALS	PARTS
Clatsop Clay	65
Ball Clay	15
Kingman feldspar	10
Fire clay	10

CONE 10 BODY

MATERIALS	PARTS
Clatsop Clay	65
Sutter Clay	15
Kingman feldspar	5
Flint	10
Fine sand	5

RESULTS OF CLAY TEST CHART ON THE CLAY FORMULAE

TEST	CONE 6 BODY	CONE 10 BODY
Water of plasticity	25%	23%
Workability	good	good
Shrinkage	16%	15%
Drying	good	good
Slumping	2	2
Absorption	5%	2%
Color	warm orange	warm brown
Dunting	none	none

COMPATIBLE GLAZE FORMULAE

The following basic glaze recipes were found to be satisfactory with the clay bodies.

GLAZES FOR CONE 6 CLAY BODY

Glossy glaze		Glossy glaze		Matt glaze	
Colemanite	55	Colemanite	20		
Kaolin	8	Zinc oxide	3		
Flint	37	Whiting	2		
		Kingman spar	44		
		Flint	24		
		Barium carbonate	6		
		Ball clay	1		

GLAZES FOR CONE 10 CLAY BODY

Glossy glaze		Matt glaze		Matt glaze	
Kingman feldspar	42.1	Nepheline synenite	56.5	Kingman spar	41
Kaolin	1.8	Barium carbonate	26	Colemanite	12
Flint	27.2	Ball clay	7.5	Dolomite	7
Whiting	2.6	Flint	7.5	EPK	5
Colemanite	8.8	Bentonite	.6	Flint	20
Dolømanite	8.8	Magnesium carbonate	10	Talc	15

APPLICATION TO A TEACHING SITUATION

The struggle between the creative process and technique is ever present in teaching art. The two are interrelated and support one another but as previously mentioned each can be taught to the exclusion of the other. It can also happen that both are emphasized but the correlation between the two is left vague. It is therefore important that the teacher directs the student towards an understanding of the relationship between the two.

The creative process is characterized in four stages. These are preparation, incubation, illumination and verification.[5] In the preparation phase one finds out what the problem is, he gathers information which is either past or acquired knowledge and he probes unknown areas, explores and develops his sensitivities to all things which contribute to his problem solving. It is a time when he keeps an open mind to possibilities. It is also a time when he learns to hold back any judgment towards a solution so that he can absorb these possibilities. Those who attempt to evaluate as they create find it extremely difficult if not impossible to develop new ideas. The student will also experience and learn to accept the uncomfortable feelings that accompany this lack of solution. The incubation period is a peculiar stage. It is the interval between the preparation and the time when an idea can seem to come from nowhere. This period ends

[5]See Richard P. Youtz, A Source Book of Creative Thinking, ed. Sidney J. Parnes and Harold F. Harding (New York, 1962), p. 194.

when a solution is found and all parts seem to fall into place. This is called illumination. Verification is the testing or trying out of the solution.

Technical knowledge, such as clay manipulation, glazing, firing, etc. must be acquired as a part of one's preparation for creative endeavor. It should become intuitive knowledge so that it does not block the path of innovation. If it does not become so then it becomes an end in itself. It should be a technical means to a creative end.

In applying the study of clay to the classroom, the teacher can give direction to the total concept of creativity but the students' interests will lie in different areas of this process. This will vary with their own growth and motivation. Some will be interested in the digging of clay, others in the testing, some in the expressive use of the clay. These interests should be developed and encouraged by the teacher with benefit to both the individual and the rest of the class. This gives each student a special place in the classroom through his unique interest.

Also, by having a personal knowledge of clay, the teacher is prepared to develop the awareness of the student, inspire his further exploration and direct him towards self-discovery. In essence, the teacher is ready to encourage when a spark appears.

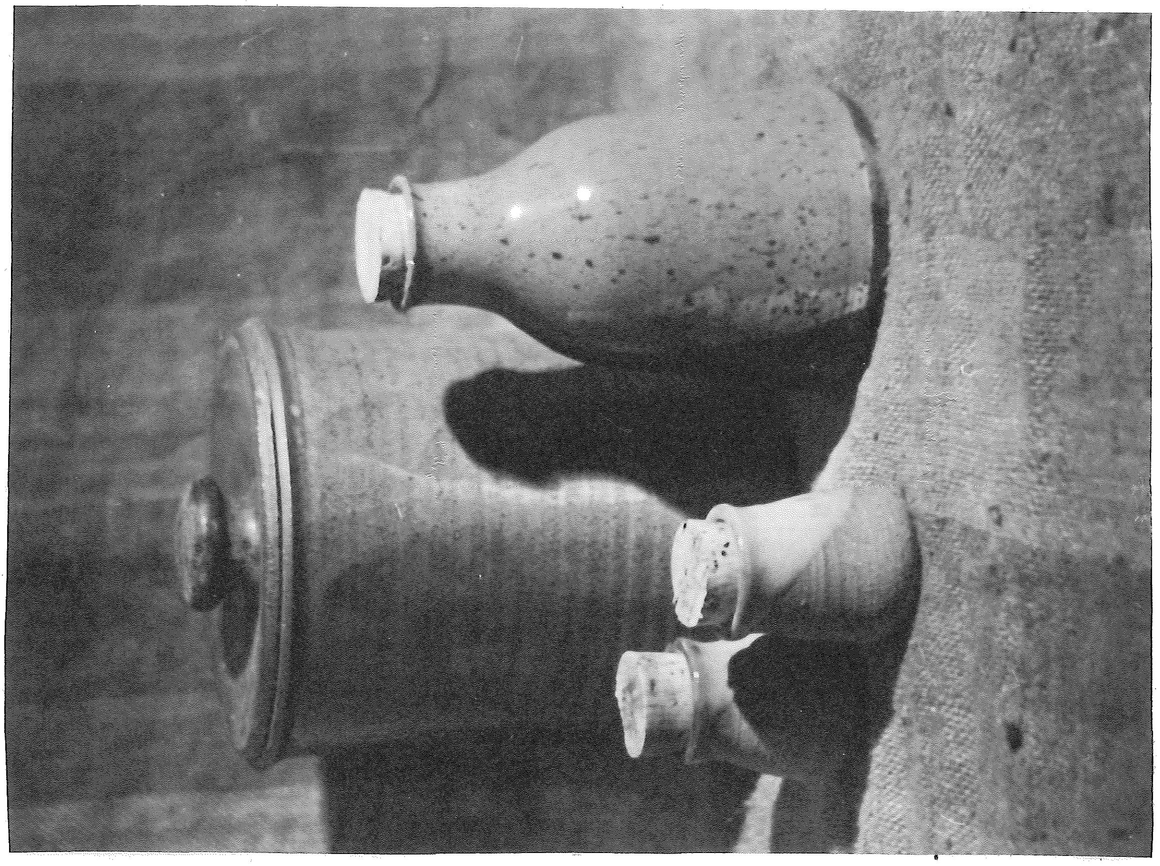
This brings us back to our present-day society which is now out of the Industrial Revolution and 20 to 30 years into the Cybernetics era. It is a time of continual change for which we must be prepared. Our schools and universities are designed to meet the needs of the

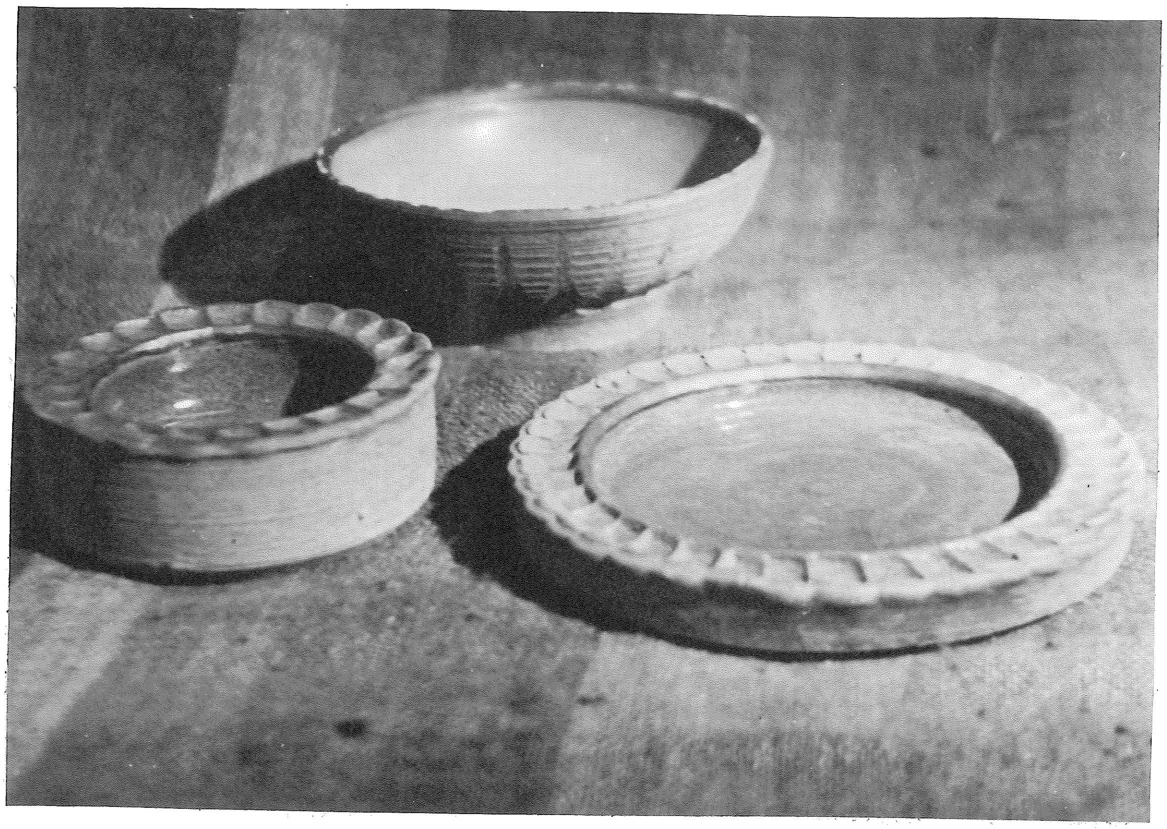
Industrial age. People can no longer be expected to spend more and more time in school absorbing vast amounts of knowledge. Instead, we must learn to develop creativity and enlarge the capacity of each individual. As Dechert points out,

> I believe the best way to do this is to change our educational process from being discipline-oriented to being problem-oriented: to set up educational systems which will force people to face all the implications of each problem and to evaluate the individual's potential in terms of his ability to perceive new interconnections between aspects of the problem.[6]

[6] Charles R. Dechert, The Social Impact of Cybernetics (London, 1966).

ILLUSTRATIONS





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